Relationship between stunting, wasting, underweight and geophagy and cognitive function of children

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Abstract

Objective

To investigate the relationship between anthropometric characteristics and both geophagy and cognitive function of children

Study design

The study prospectively followed singleton children whose mothers participated in the MiPPAD clinical trial in Allada, Benin, from birth to age 12 months. Anthropometric measurements were taken at birth, 9 months and 12 months. Wasting, stunting and underweight were defined as weight-for-length, length-for-age and weight-for-age *Z*-scores less than -2, respectively. Cognitive and motor functions were assessed using the Mullen Scales of Early Learning (MSEL). Parent-reported geophageous habits of children were collected when the children were 12 months. Multiple linear and logistic regressions were used to analyse the data.

Results

A total of 632 children (49.7% girls) were involved in the study. Stunting, wasting and underweight were observed in 14.1%, 13.6% and 17.7% respectively at 9 months and 17.3%, 12.7% and 17.2% respectively at 12 months. The prevalence of geophagy among the children was 48.2%. Impaired growth at 9 and 12 months were consistently associated with low cognitive and gross motor score. Children stunted at 9 months had lower GM scores at 12 months compared to their non-stunted peers [β = -3.48, 95% CI (-6.62, -0.35)].

Conclusions

Stunting, wasting and underweight are associated with cognitive and gross motor deficits in infants. In this setting, impaired growth was not associated with geophagy. Further research evaluating geophagy and growth prospectively and concurrently from birth to 36 months is needed.

Keywords: child development, pica, geophagy, stunting, wasting, Benin

Introduction

The physical and intellectual developments of children influence their overall development later in adolescence and adulthood. In many low and middle-income countries (LMICs), the proportion of children who fail to meet growth and development milestones remains disproportionately high in comparison to children in high-income countries[1]. According to a report by the United Nations Children's Fund (UNICEF), sub-Saharan Africa and south Asia account for about 75% of 165 million stunted children globally thus stunting and wasting remains important public health concerns in LMICs [2]. In sub-Saharan Africa, approximately 40% of all children under the age of 5 years are stunted [2].

Impaired growth in childhood, measured as stunting or wasting, has been linked with poor cognitive development and academic performance[3,4]. In preschool-aged children, a number of studies have reported a relationship between stunting and wasting and suboptimal motor functions, poor non-verbal reasoning, and substandard cognitive development[5,6]. In a study among 54 to 60 month-old children in rural Ethiopia, stunted children were found to perform significantly lower on school-readiness tests compared to non-stunted children[6]. A similar relationship has been reported in studies involving children under the age of 5 years. A study by Casale *et al* showed that even 2-year-old stunted children who recovered by age 5 years still performed poorer on cognitive tests compared to their counterparts who were not stunted at age 2 years[7].

The determinants of suboptimal growth and cognitive development among children living in LMICs include poverty, limited access to healthcare and malnutrition. Stunting, wasting and underweight have been used as global indicators for chronic and acute malnutrition although they could also be as a result of impaired health[8]. In a recent prospective study by George *et al*, it was found that the risk of stunting among children under 5 years old was twice higher if they were reported to consume soil, a form of pica called geophagy[9]. Geophagy is common among children and the practice has been associated with increased risk of diarrhoea, helminth infection and impaired child growth [9,10] however very little is known of the interrelationship between stunting, cognitive function and geophagy behaviour among children.

Hence, as part of a study of the effect of maternal anaemia during pregnancy on infant cognitive development [11] geophagy among children was investigated as a potential source of elevated blood lead levels in children[12] born in a semi-rural community in Benin. We hypothesized that stunting, wasting and underweight at 9 and 12 months are independently associated with the risk of geophagy and poor cognitive function of 12-months-old children.

Methods

This study involved singleton children born to HIV-negative pregnant women who were enrolled in the MiPPAD clinical trial (NCT00811421) comparing the efficacy and tolerability of Mefloquine and Sulfadoxine-Pyrimethamine as intermittent preventive treatments of malaria[13]. The study was conducted in Allada, a semi-rural community located 50km to the northwest of Cotonou (Figure 1). Nine months after birth, anthropometric data was taken from surviving children. At age 12 months, singleton children were invited to participate in a study called *Tovi* that assessed their cognitive function using the Mullen Scales of Early Learning (MSEL). Blood samples collected from these children in May 2011 revealed elevated blood lead toxic levels in this children which warranted an investigation into the potential sources of lead among which geophagy in children was considered[12]. In November 2011, questionnaires about the nutritional and geophagy habits of children were administered to all parents including those whose children had already completed the MSEL assessment in the past one to two years.

Since this is a secondary analysis of an unintended study investigating the sources of elevated blood lead levels in children[12], the method below will outline the sequence of steps that was undertaken from data collection to statistical analysis.

Weight and gestational age were recorded at birth. Anthropometric measurements of children were taken during scheduled clinic visits at 9 and 12 months after their birth. Weight (to the nearest 10 g) and incumbent length (to the nearest 1 mm) of children were measured using a calibrated electronic scale (SECA type 354) and a locally manufactured wooden measuring scale, respectively. Trained research nurses performed cognitive assessments. Z-scores for the weight-for-length (WLZ), length-for-age (LAZ) and weight-for-age (WAZ) of all the children in our study were estimated using the 2006 World Health Organization (WHO) Child Growth Standards as a reference for each indicator [14]. Stunted growth was defined as LAZ less than -2 whereas wasting, a characteristic associated with acute starvation and/or severe malady, was defined as WLZ less than -2. Underweight was defined as WAZ less than -2.

Cognitive assessments and information on the socioeconomic status and conditions of the home environment were collected during scheduled clinic visits and home visits when the child was 12-months-old. During the scheduled clinic visit, cognitive and motor functions were assessed using the Mullen Scales of Early Learning (MSEL)[15]. The MSEL used for this study was a translated version [16] that was adapted for this particular setting. Research nurses were trained on the field to administer the MSEL. Quality assurance and reliability were carried out and have been published elsewhere[16]. The MSEL comprises of 5 main scales: the gross motor (GM), fine motor, visual reception, receptive language and expressive language. The raw scores obtained by children in the different MSEL scales were transformed to age-normalized (monthly) scores called the *t*-scores. *T*-scores for all but GM scores were then combined to form the Early Learning Composite (ELC) score, which is indicative of early cognitive function. The standardized ELC and GM scores were considered outcomes indicating cognitive and motor functions, respectively.

Within 3 days after anthropometric and cognitive assessment were taken, a different research nurse visited the child at home. During the home visits, socioeconomic status of the household, maternal non-verbal IQ, postnatal depression, and the home environment of the child were assessed. Maternal non-verbal intelligence quotient (IQ) measured using Raven's Progressive Matrices[17], the maternal-child interaction and the growing environment of the child measured using the Home Observation Measurement of the Environment (HOME) inventory[18], and maternal postnatal depression measured using the Edinburgh Postnatal Depression Scale (EPDS)[19]. A sum of scores given to facilities and possessions in the home of the mother including electricity, car, motorcycle, television, radio, bicycle and cattle was used to estimate the family possessions score. Details of how the scoring was done are published elsewhere[20].

From November 2011 to May 2013, mothers were administered questionnaires about nutritional habits, hand to mouth habits and geophagy behaviour among children during a home visit. With respect to geophagy behaviour, mothers were asked if they have seen their children consume earth in the past month.

Statistical analysis

Double data entry was performed using EpiData 3.1 (Denmark) and verified for coherence. Statistical analyses were conducted using Stata IC/14.1 for Mac (StataCorp Lp, College station, TX).

Distributional analysis and descriptive statistics were performed for all variables independently. We then compared the characteristics of children with geophagy assessment to those without geophagy assessment at 12 months. Stunting, wasting and underweight were considered separately as primary independent variables whereas geophagy, standardized ELC and GM scores were considered as the dependent variables in the analyses. Bivariate relationships between geophagy, ELC score, GM score and child and mother characteristics were assessed and covariates with *P*-value less than 0.20 were selected for the multiple regression analysis (adjusted models).

Linear regression analysis was used to assess the relationship between stunting, wasting and underweight at 9 and 12 months and the ELC and GM scores in crude (Model I) and adjusted (Model II) models. Unconditional logistic regression was used to assess the relationship between stunting, wasting and underweight and geophagy in crude (Model I) and adjusted models (Model II). In the adjusted models, covariates were removed in a stepwise manner if the *P*-value was greater than 0.05.

The student *t*-test, Wilcoxon rank sum test and chi-squared test were used to compare means, medians and proportions, respectively. Statistical significance was defined as *P* less than 0.05.

Ethical consideration

The *Tovi* study was approved by the institutional review boards of the University of Abomey-Calavi in Benin and New York University in USA and the Research Institute for Development's (IRD) Consultative Ethics Committee in France. Informed consent was sought from every mother in the presence of a witness at recruitment during the study. Mothers provided thumbprints to confirm their agreement to participate in the study if they who could not read and write after the study had been explained to them in a local language.

Results

A total of 632 singleton children (49.7% girls) were involved in this study. At 9 months the prevalence of stunting, wasting and underweight was 14.1%, 13.6% and 17.7%, respectively (Table 1). Data on child geophagy at 12 months were only available for 193 children among whom the prevalence of parent reported geophagy was 48.2%. Almost all children (99.0%) were being breastfed at 12 months. Except for maternal education, gestational age, proportion of wasting at 9 months and underweight at 12 months, the characteristics of children who had geophagy assessment were similar to those who did not have this assessment at 12 months (Supplementary Table 1). Figure 2 shows the prevalence of geophagy among children with and without impaired growth. The prevalence of geophagy was similar for children with impaired growth at 9 and 12 months except for the underweight group at 12 months (Figure 2). The prevalence of parent-reported geophagy among the 12-months-old non-underweight children was significantly higher than that of the underweight children (55.0% versus 27.3%, $P<0.05$). Although children with impaired growth at 9 and 12 months had lower ELC scores and component scores of the MSEL compared to those with no impaired growth, this was less so for receptive language (Table 2). Children without impaired growth consistently scored higher on motor scales compared to those with impaired growth. As expected, hand-to-mouth behaviour (not necessarily ingesting any substance) was significantly common among geophageous children. Of the sociodemographic and behavioural characteristics, only hand-to-mouth behaviour and maternal IQ scores were associated with geophagy at 12 months.

There was no association between any of the indicators of growth impairment at 9 and 12 months and geophagy at 12 months. This was consistent in crude and adjusted models. Wasting and underweight at 9 months were associated with lower ELC and GM scores at 12 months. Children who were stunted at 9 months had lower GM scores at 12 months compared to those who were not stunted at 9 months [β = -3.48, 95% Confidence interval, CI (-6.62, -0.35)]. A similar inverse relationship was observed between stunted growth at 9 months and ELC scores in the adjusted model, however it was not statistically significant (P= 0.063). Stunted growth and underweight at 12 months were associated with worse cognitive and motor functions (Table 4). Compared to children who were not wasted at 12 months, wasted children scored lower on the GM scale assessments [β = -4.91, 95% CI (-8.14, -1.67)].

Discussion

This study reveals a relatively high prevalence of stunting, wasting and geophagy behaviour among children in Allada, Benin. From the results, growth impairments at 9 and 12 months were not associated with increased risk of geophagy at age 12 months. Inverse associations between impaired growth and cognitive function of children were generally apparent for both impaired growth at 9 and 12 months. Also, children who were stunted, wasted or underweight at 9 and 12 months had worse gross motor function compared to their counterparts who were not stunted, wasted or underweight.

The achievement of linear growth potential by children is essential for their growth and development later in life. According to the WHO, wasting is deemed critical in a population if the prevalence equals or exceeds 15% which is the category our study population falls [21]. Stunting, wasting and underweight are indicators of impaired growth potential and are usually caused by malnutrition or chronic disease [22]. During infancy (0 – 24 months), a healthy child experiences rapid growth not just in physical features but also in brain development [23]. Thus, impaired maximum growth velocity due to undernutrition is likely to lead to impaired brain development and as a result delayed cognitive development. This may explain the strong association between poor cognitive and gross motor functions and stunting in this study. The findings of the present study are consistent with earlier published studies [24,25]. Although wasting may not necessarily be indicative of any chronic conditions, such sudden weight loss and its underlying causes during the most important period of child development could also impair the cognitive and motor developments of the child.

The aetiology of impaired growth in children is multifactorial but, in our population, this is unlikely due to breastfeeding as 99% of our study were still being breastfed at 12 months. However, we did not assess whether breastfeeding was exclusive or partial. Impaired growth in children as a result of malnutrition or disease could result in decreased glial cell numbers and problems with cortical dendrite branching[26,27]. These neurocognitive insults could impair the cognitive development and motor functions of children[28]. However, in our study, except for stunting at 12 months, we did not notice any difference in receptive language between children with impaired growth and those with normal growth. Precursors of language development such as fine and gross motor gestures begin early in life but differences in language reception between children with and without impairments become apparent later in childhood when recognition of everyday words becomes noticeable[29]. A study in Ecuador found that language deficits in children from low SES home increased from age 36 to72 months compared with children from a high SES home[30]. This may explain why we found no difference in receptive language by impaired growth status at 9 and 12 months.

In the present study, we hypothesised that children with impaired growth are at high risk of poor motor function will have less contact or playtime on the ground and thus maybe consume less soil. However, we found no significant association between impaired growth (stunting, wasting and underweight) and geophagy although stunting at 9 and 12 months were associated with low gross motor scores. The absence any observed association between impaired growth and geophagy should be interpreted cautiously as post hoc power analysis revealed that we did not have sufficient power to report any association for this particular analysis. The insufficient power was due to the small sample of children for whom geophagy was assessed coupled with the few numbers of children with impaired growth.

Further, hand-to-mouth behaviour is common among 0 to 24-months-old children[31], in this study similar prevalence to geophagy. Thus, there could be potential measurement errors with the assessment of geophagy as mothers may have reported hand-to-mouth behaviour as geophagy even when children did not consumed soil.

Contrary to our study, the only previous research on the subject investigated geophagy as a risk factor of impaired growth including stunting in a sample of 216 children[9]. In the aforementioned study, investigators found caregiver-reported geophagy to be associated with increased risk of environmental enteropathy and stunting in childhood. The study however reported no statistically significant relationship between observed or caregiver-reported geophagy in children and underweight or wasting[9], results similar to our findings. In addition to the aforementioned study considering geophagy as a risk factor, the study sample was on average older (6 months to 5 years) than those in this study. That notwithstanding, we run post hoc analysis considering geophagy as risk factor of stunting and wasting in order to validate the findings of the aforementioned study and we found no significant association between stunting or wasting and geophagy. It is however worthy of note that the authors found that the 6 to 12 months age group exhibited the most geophagy behaviour[9]. Later publication from these authors reported that children less than 24-months-old were 8 times more likely to practice geophagy compared to those older than 24 months[32].

Although the present study used longitudinal data from birth, 9 and 12 months, we did not assess geophagy habits at 9 months. Our analysis of the relationship between impaired growth measures and geophagy therefore bears the classic limitations of cross-sectional studies including potential reverse causality, inability to access temporality and inability to make causal inferences between the exposures and outcomes examined. Our study is further limited in the retrospective assessment of geophagy in children, which could have potentially led to recall bias in the assessment of exposure among respondents although we would expect this to be non-differential. The retrospective assessment of geophagy also did not allow us to assess the quantity and frequency of soil consumption during the period of assessment as well as the physicochemical properties of the type of soil they consumed. This is particularly important as previous research suggested an increased risk of geophagy for children whose mothers were geophageous during pregnancy[33]. We intend to address these limitations in a follow-up study among the same cohort of children at age 6 years. Notwithstanding these limitations, our study is strengthened by the prospective assessment of anthropometric information at 9 and 12 months. Also, the use of a standardized cognitive assessment battery, the MSEL, which was adapted to the study settings, permitted us to better assess cognitive functions of children. We also accounted for several factors that could have confounded the association between stunting, wasting, underweight and cognitive function and motor functions.

In conclusion, stunting, wasting and underweight are associated with cognitive and gross motor deficits. The findings of this study contribute to our understanding of the relationship between cognitive and motor development and geophagy in childhood. To our knowledge, this study is the first to investigate the associations between stunting, wasting and underweight in 9 and 12 months and the risk of geophagy and poor cognitive function of 12-months-old children in Benin. In this study setting, impaired growth was not associated with risk of geophagy. Further research is needed to evaluate both geophagy and growth prospectively at the same time from birth to at least 36 months of age.

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Legends to figures:

Figure 1. Map showing the location of Allada (the study site) in Benin

Figure 2. Prevalence of geophagy among children with impaired and normal growth at 9 and 12 months

Table 1. Characteristic of study participants

N=632	Number	Mean (SD)
Maternal Characteristics		
Age at 1st ANV (years)	627	26.0 (5.7)
Family possession score[a]	627	5 (3 – 9)
Maternal IQ score[a]	626	15 (13 – 17)
EPDS score[a]	623	8 (5 – 11)
Education[b]		
Primary or more	214	33.9
Never schooled	418	66.1
Occupation[b]		
Employed	315	50.2
Housewives	312	49.8
Gravidity[b]		
Multigravida	513	81.8
Primigravida	114	18.2
At Birth		
Birth weight (kg)	627	3.0 (0.4)
Normal weight (≥ 2500 g) [b]	566	90.3
Low Birth weight (< 2500 g) [b]	61	9.7
Gestational age (weeks)	609	39.7 (2.2)
Not Preterm	566	92.9
Preterm	43	7.1
Sex		
Girls	314	49.7
Boys	318	50.3
At 9 months		
Weight (kg)	618	7.7 (1.1)
Height (cm)	618	69.5 (3.2)
Stunted Growth		
Yes (LAZ < -2SD)	87	14.1
No (LAZ ≥ -2 SD)	530	85.9
Wasted		
Yes (WLZ < -2SD)	84	13.6
No (WLZ ≥ -2 SD)	533	86.4
Underweight		
Yes (WAZ < -2SD)	109	17.7
No (WAZ ≥ -2 SD)	508	82.3
At 12 months		
Weight (Kg)	632	8.4 (1.1)
Height (cm)	632	72.6 (3.2)
Stunted Growth		
Yes (LAZ < -2SD)	109	17.3
No (LAZ ≥ -2 SD)	523	82.7
Wasted		
Yes (WLZ < -2SD)	80	12.7
No (WLZ ≥ -2 SD)	552	87.3
Underweight		
Yes (WAZ < -2SD)	109	17.2
No (WAZ ≥ -2 SD)	523	82.8
Hand-to-mouth		
Yes	84	43.5
No	109	56.5
Geophagy		
Yes	93	48.2
No	100	51.8
Breastfeeding		
Yes	620	99.0
No	6	1.0

[a] Values in the third column are presented as Median (Inter Quartile Range); [b] Values in the third column are presented as Percentages; ANV- Antenatal Care Visit; BMI- Body Mass Index; IQ- Intelligence Quotient; EPDS - Edinburgh Postnatal Depression Scale; LAZ- Length-for-Age Z scores; WLZ- Weight-for-Length Z scores; WAZ- Weight-for-Age Z scores.

Table 2. Comparison of mean standardized scores of MSEL scales between children with impaired growth and those without impaired growth

	Fine Motor	**Visual Reception**	**Language Expression**	**Language Reception**	**Early Learning Composite**	**Gross Motor**
<u>At 9 months (n= 617)</u>						
Stunted Growth						
Yes (LAZ < -2SD)	46.8 (10.6)	48.7 (12.1)	47.3 (12.0)	45.4 (7.4)	95.0 (16.0) ǂ	46.0 (16.1)
No (LAZ ≥ -2 SD)	50.3 (9.9) ǂ	50.7 (10.5)	50.0 (10.2) *	46.8 (6.7)	99.3 (13.7)	51.7 (14.1) #
Wasted						
Yes (WLZ < -2SD)	45.0 (10.1)	46.1 (11.7)	48.4 (11.1)	45.4 (7.6)	93.0 (16.0)	45.7 (16.0)
No (WLZ ≥ -2 SD)	50.6 (9.8) #	51.1 (10.5) #	49.8 (10.4)	46.8 (6.7)	99.6 (13.6) #	51.7 (14.2) #
Underweight						
Yes (WAZ < -2SD)	45.9 (10.0)	47.9 (12.1)	47.7 (11.3)	45.8 (7.4)	94.2 (16.4)	46.0 (15.8)
No (WAZ ≥ -2 SD)	50.7 (9.9) #	51.0 (10.4) ǂ	50.1 (10.3) *	46.8 (6.7)	99.6 (13.4) #	51.9 (14.1) #
<u>At 12 months (n=632)</u>						
Stunted Growth						
Yes (LAZ < -2SD)	46.2 (9.9)	48.0 (11.7)	46.7 (10.8)	44.8 (5.9)	93.6 (14.2)	44.3 (14.1)
No (LAZ ≥ -2 SD)	50.6 (9.9) #	50.9 (10.6) *	50.3 (10.3) ǂ	47.0 (6.9) ǂ	99.8 (13.9) #	52.3 (14.2) #
Wasted						
Yes (WLZ < -2SD)	47.1 (10.1)	50.8 (10.8)	48.6 (11.3)	46.9 (7.8)	99.2 (13.8)	45.7 (15.0)
No (WLZ ≥ -2 SD)	50.3 (9.9) ǂ	47.7 (11.0) *	49.8 (10.4)	46.6 (6.7)	95.6 (15.6) *	51.7 (14.3) #
Underweight						
Yes (WAZ < -2SD)	45.6 (9.7)	47.5 (12.8)	47.4 (11.8)	45.9 (7.2)	93.8 (16.4)	45.3 (15.4)
No (WAZ ≥ -2 SD)	50.8 (9.8) #	51.0 (10.3) ǂ	50.1 (10.2) *	46.8 (6.7)	99.7 (13.4) #	52.1 (14.1) #

# *P*<.001; ǂ *P*<.0.01; **P*<0.5

Values are presented as Mean (SD) throughout the table

MSEL – Mullen Scales of Early Learning; LAZ – Length-for-Age *Z*-scores; WLZ –-Weight-for-Length *Z*-scores; WAZ – Weight-for-Age *Z*-scores

Table 3. Bivariate relationships between sociodemographic characteristics and geophagy, ELC scores and GM scores

	Geophagy			ELC scores		GM scores	
	Mean (SD)	Mean (SD)	*P*	Mean (SD)	*P*	Mean (SD)	*P*
<u>Maternal Characteristics</u>							
Age at 1st ANC visit (years)	25.8 (5.4)	26.1 (5.2)	0.674	0.0 [b]	0.494	0.1 [b]	0.145
Family possession score	5 (4; 8) [a]	5 (4; 8) [a]	0.449	0.1 [c]	0.002	0.1 [c]	<0.001
Maternal IQ score	14 (12; 16) [a]	15 (14; 17) [a]	0.020	0.1 [c]	0.135	0.1 [c]	0.002
EPDS score	8 (4; 12) [a]	6.5 (4; 10) [a]	0.142	0.0 [c]	0.915	0.0 [c]	0.570
Education, n (%)							
Primary or more	28 (28.0)	25 (26.9)	0.862	102.8 (12.2)	<0.001	53.9 (15.2)	<0.001
Never schooled	72 (72.0)	68 (73.1)		96.6 (14.6)		49.4 (13.9)	
Occupation, n (%)							
Employed	44 (45.4)	49 (53.2)	0.278	100.9 (13.2)	<0.001	52.7 (15.1)	0.003
Housewives	53 (54.6)	43 (46.7)		96.4 (14.7)		49.2 (13.7)	
Gravidity, n (%)							
Multigravida	78 (80.4)	80 (87.0)	0.225	98.4 (14.2)	0.382	51.6 (14.1)	0.016
Primigravida	19 (19.6)	12 (13.0)		99.7 (13.6)		48.0 (15.7)	
<u>At Birth</u>							
Birth weight (kg)	3.0 (0.4)	3.1 (0.5)	0.293	0.0 [b]	0.238	0.1 [b]	0.006
Gestational age (weeks)	39..4 (1.8)	39.4 (1.9)	0.786	0.1 [b]	0.004	0.1 [b]	0.013
Sex, n (%)							
Girls	53 (53.0)	48 (51.6)	0.847	99.6 (14.6)	0.115	50.1 (14.2)	0.166
Boys	47 (47.0)	45 (48.4)		97.8 (13.5)		51.7 (14.7)	
<u>At 9 months</u>							
Crawling, n (%)							
Yes	92 (92.0)	85 (92.4)	0.920	99.1 (13.9)	0.060	52.3	<0.001
No	8 (8.0)	7 (7.6)		95.8 (15.4)		40.3	
Age at first crawl	92 (6.7)	85 (6.8)	0.618	-0.1 [b]	0.029	-0.2 [b]	<0.001
<u>At 12 months</u>							
HOME Score	27.2 (2.1)	270 (2.2)	0.438	0.2 [b]	<0.001	0.2 [b]	<0.001
Hand-to-mouth, n (%)							
Yes	71 (71.0)	38 (40.9)	<0.001	–	–	–	–
No	29 (29.0)	55 (59.1)		–		–	

[a] Values are presented as Median (Inter Quartile Range); [b] Values are presented as Pearson correlation; c Values are presented as Spearman correlation;
ELC – Early Learning Composite; GM – Gross Motor; ANC – Antenatal Care; BMI – Body Mass Index; IQ – Intelligence Quotient; HOME – Home Observation Measurement of the Environment; NA – Not Applicable.

Table 4. Regression models showing the association between stunting and wasting, and geophagy, ELC and GM scores

		Geophagy	ELC score[a]	GM score[b]
		OR (95% CI)	β (95% CI)	β (95% CI)
At 9 months				
Stunted	Model I	1.31 (0.61; 2.79)	-4.29 (-7.48; -1.10)≠	-5.64 (-8.92; -2.36)≠
	Model II	NS	-3.08 (-6.33; 0.16)	-3.48 (-6.62; -0.35)*
Wasted	Model I	0.67 (0.22; 2.01)	-6.63 (-9.85; -3.42)#	-6.05 (-9.37; -2.72) #
	Model II	NS	-5.54 (-8.78; -2.29)≠	-4.18 (-7.34; -1.03)*
Underweight	Model I	0.83 (0.37; 1.88)	-5.43 (-8.33; -2.53)#	-5.90 (-8.88; -2.92) #
	Model II	NS	-4.07 (-6.99; -1.15)≠	-4.07 (-6.91; -1.22)≠
At 12 months				
Stunted	Model I	1.47 (0.71; 3.04)	-5.82 (-8.69; -2.96) #	-7.89 (-10.81; -4.98)#
	Model II	NS	-4.84 (-7.74; -1.95)≠	-5.78 (-8.66; -2.91)#[c]
Wasted	Model I	0.76 (0.32; 1.79)	-3.56 (-6.87; -0.26)*	-5.94 (-9.32; -2.56)#
	Model II	NS	-2.72 (-5.99; 0.54)	-4.91 (-8.14; -1.67)≠[c]
Underweight	Model I	0.31 (0.11; 0.83)	-5.90 (-8.79; -3.02)#	-6.78 (-9.74; -3.82)#
	Model II	NS	-4.42 (-7.34; -1.51)≠	-4.82 (-7.70; -1.94)≠

# P<.001 ≠ P<.0.01 *P<0.5

Model I – Crude model; Model II – Adjusted model

[a]Adjusted for gestational age at birth, maternal education, and HOME score; [b]Adjusted for maternal pre-pregnancy BMI, maternal education, HOME score, and crawling at 9 months; [c]Adjusted for maternal pre-pregnancy BMI, maternal education, and crawling at 9 months.